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AQUACULTURE IN CANADA

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AQUACULTURE IN CANADA

INTRODUCTION

A. World Trends

Aquaculture is the cultivation of aquatic organisms, including finfish, shellfish (molluscs and crustaceans) and aquatic plants. As in agriculture, aquaculture implies some form of intervention - regular stocking, feeding or protection from predators - as well as individual or corporate ownership of the stocks being cultivated. The activity has a long history: the first traces of fish farming date back several centuries to China, where it was a common practice to raise carp in rice paddies.(1) Today, aquacultural production is estimated to make up over 14% of the world's total aquatic harvest.(2) In terms of quantity, carp, tipalia, catfish and yellowtail are the most important finfish cultivated worldwide; in terms of value, salmon, eels, trout, catfish and yellowtail dominate. The most prominent type of farmed crustacean is shrimp, mainly because of high consumer demand in the three major seafood markets - Japan, the United States and Europe. Oysters, mussels and scallops account for the lion's share of mollusc production.

On a world scale, the harvest is highly concentrated in Asia, which accounts for well over 80% of the total and where aquaculture

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(1) "China: World Watch," *Pacific Fishing,* May 1991, p. 19.

(2) "World Watch," *Pacific Fishing,* November 1990, p. 19. Since production figures have only recently begun to be collected systematically in some countries, there are many gaps in the information available. Cultured molluscs account for about 79% of total supply, seaweed for 75%, finfish 7%, and crustaceans 4%.

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is a traditional activity aimed at supplying essential protein for local consumption. In developing countries, the species reared are generally of lower value but easy and inexpensive to cultivate; in more advanced industrialized countries, they are more often carnivorous, requiring more care in husbandry and more capital investment. The industrialized countries of the Organisation for Economic Co-operation and Development (OECD) produce about 25% of total world output, and this is concentrated mainly on high-value "luxury" species with generally low volume yields.(3) Aquaculture in OECD member countries is, above all, a commercial activity and one that has seen considerable growth as investors have been attracted by potential high rates of return.(4)

Besides the steady rise in demand for fish products(5) and aquaculture's continuity of supply, consistency of quality, and control over production (e.g., size, fat content), the growth of this activity has been spurred by scientific advances in nutrition, disease control and genetics, as well as technological developments in designing installations (e.g., aeration and pumping systems, monitoring and control systems). Although shellfish are particularly popular, aquaculture around the world covers an increasingly broader range of species. Aquaculture is gaining momentum and the cultured production of even "simple" species such as Atlantic cod has been considered. In the southern United States, pond-raised catfish is being processed at an annual rate of over 167,000

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(3) The OECD includes Australia, Austria, Belgium, Canada, Denmark, Finland, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States.

(4) Ulf Wijkström, "Aquaculture in the 1990s: Major Issues for Public Policies," in *Aquaculture: Developing a New Industry*, Organisation for Economic Co-operation and Development, Paris, 1989, p. 33.

(5) In the United States, for example, the consumption of seafood steadily increased from about 12.8 pounds per person in 1980 to a record 15.9 pounds in 1989. The U.S. National Fisheries Institute forecasts the per capita amount will be close to 20 pounds by the year 2000.

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tonnes,(6) and its consumption in the U.S. is predicted to triple by the turn of the century.(7) In 1990, world production of farmed shrimp is estimated to have increased by 12% to a record 633,000 tonnes - 25% of the total 2.6 million tonnes harvested that year. The bulk of cultivated shrimp is produced in the tropical regions of the world (especially in South Asia and South America, which have lower operating costs). If production continues to expand at the present level, cultured shrimp will capture 50% of the total market by the end of the century.(8) By that time, it is expected that the global supply of all fish and shellfish from aquaculture will be five to ten times larger, "given the necessary scientific and organizational support."(9)

Two arguments are usually advanced by those who believe that aquaculture deserves increased government recognition and support. The first argument is that aquaculture contributes to economic growth, especially of durable employment and income, in areas where alternatives are few; the second is that aquaculture will fill a projected shortfall of fishery products caused by stagnation in the traditional capture fisheries.(10) Resource economists assert that most major stocks of familiar fish have either been fully exploited or are being excessively harvested and that "the growth era in fisheries is over." Thus, marine and

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(6) "Aquaculture Situation and Outlook," *Seafood Trend Newsletter,* 29 October 1990, p. 1.

(7) "Catfish: Market Report," *Seafood International,* March 1991, p. 5.

(8) "Record Shrimp Production: Market Report," *Seafood International,* March 1991, p. 5; Charles J. Peckman (LMR Fisheries Research Inc.), *The Potential Effects of Cultured Shrimp Production on the Principal International Markets and Canadian Cold Water Shrimp Demand,* DFO Economic and Commercial Analysis Report No. 61, May 1990.

(9) World Commission on Environment and Development, *Our Common Future,* 1987, p. 138.

(10) By the end of the decade, the world's population is expected to reach 6.1 billion. Even if global consumption of seafood were to remain at the 1988 level (13.6 kilograms liveweight per person), total seafood landings of some 83.1 million tonnes, or an increase of 13.4 million tonnes over the current food harvest, would be required by the year 2000. Accessing or creating supply will therefore pose the greatest challenge to the world's fish producers in the 21st century.

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freshwater aquaculture may relieve increasing fishing pressures on wild stocks. There are, however, major constraints on the further development of aquaculture; these include production costs; government attitudes; policies and regulations concerning pollution, site selection and water quality; and market conditions.

B. Major Constraints to Further Global Development

The main costs of production (except for farmed molluscs and algae) is man-made feed. Most feed components used have a high proportion of fish meal, which has a high protein content.(11) Aquaculture competes for fish meal with other sectors, especially agriculture (e.g., poultry and pork production) where fish meal is also valued as animal feed. Questions arise as to whether there will be future shortages of fish for reduction purposes (as a result of growing demand for direct human consumption, or the development of new processing techniques such as those in the manufacture of surimi), and whether increases in price will have a dampening effect on further production. The aquaculture industry thus faces, at least in theory, what is known as the "feed cost barrier" or the "fish meal trap."

Aquaculture systems can, however, rely, to a larger extent, on the natural productivity of marine and freshwater environments without recourse to feeding with man-made feeds (e.g., enhancement or restocking, transplanting, the cultivation of molluscs and algae). "Ocean ranching," for example, comprises activities "in-between" capture fisheries and traditional aquaculture, and has had some success with salmon.(12) In

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(11) As a rule of thumb, for every 3 kilograms of fish transformed into fish meal and included in fish feed, 1 kilogram of cultured product is obtained: Wijkström (1989), p. 28.

(12) A sizeable increase in the total world supply of salmon since the late 1970s can be attributed to increases in Alaska's production. Cited as a major reason for this phenomenon is the supplemental production of state hatcheries and private non-profit hatcheries practising "salmon ranching," a technique which promotes the anadromous return of adult salmon, like that of wild stocks, after hatchery releases of fry. The scope of this paper is limited, and hence will disregard fish-raising activities geared to resource enhancement, such as U.S. state hatcheries or Canada's Salmonid Enhancement Program (SEP) on the Pacific Coast.

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Japan, apart from the enhancement of both salmon and molluscs, stocks of five species of finfish and two species of crustaceans of the inland sea of Japan are regularly enhanced.(13) The choice between traditional aquaculture and sea ranching is largely an economic one; for example, salmon's relatively low return to its place of release in sea ranching must be weighed against the costs of investment in production sites and the costs of ongoing operations. The extent to which ocean ranching is possible is also debatable: some have argued that, overall and in the long run, the nutrients of the sea are fully used by the existing flora and fauna, and that for this reason it is unrealistic to expect much from ranching exercises. Others, however, argue that the difficulty lies in finding areas and environments suitable for reproduction. Nevertheless, with engineering progress (e.g., oceanic, genetic and communications), the tools and knowledge needed for sea ranching will likely improve. The extent to which "wanted" species would then be favoured at the expense of "unwanted" ones could cause fisheries managers increasing difficulties.

The environmental issues that need to be addressed include fish farming and the spread of pathogens through the ill-considered or indiscriminate introduction or transfer of exotic or natural stocks. The trend in European aquaculture and elsewhere has been towards intensive operations, which can bring increased risk of disease. In salmon cage farming, for example, not only could diseases limit production and affect mortality rates,(14) but changes in natural populations could occur, such as the loss of genetic fitness of some natural stocks because of the reduction in diversity.(15)

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(13) Wijkström (1989), p. 34.

(14) One example is ulcerative dermal necrosis (UDN). Although not yet detected in Canada, this disease has, in the past, devastated many Atlantic salmon populations in Europe.

(15) Kjetil Hindar, "Genetic Effects of Cultured Fish on Natural Fish Populations," *Canadian Journal of Fisheries and Aquatic Sciences*, Vol. 48, No. 5, May 1991, p. 945-957.

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The industry's expansion in near-shore areas will likely become increasingly difficult due to a general shortage of unpolluted sites that are accessible and productive. Concerns have been expressed over the influence of wastes (organic material from fish) and chemical residues (excess feeds, vaccines and anti-bodies) settling on the bottom of lakes, rivers and coastal areas. Production, especially in highly-intensive systems, is dependent on sufficient quantities of high-quality water. Usually this poses few major problems when operations are sea-based, as long as there are reasonably favourable currents. Land-based installations using fresh water, on the other hand, are much more fragile and the outgoing water contains greater concentration of pollutants. In areas where there is poor water recirculation or where waste discharge problems already exist, an aquaculture operation may result in excessive pollution. Hence, to reduce the risk for both the operation and for downstream users of the discharged water, strict regulatory controls are required.(16) Finally, the space occupied by aquaculturists cannot be used for recreational purposes or for the traditional fisheries so that conflicts over development have arisen worldwide.(17)

Cultivated seafood has been readily accepted by consumers, and most farmed fish are perceived as high-quality luxury products. There is, however, a limit to how much the market is willing to pay because the products of the traditional capture fisheries and other foodstuffs are considered to be an easy substitute for farmed fish. Because of its small share in present overall food consumption, and the hypothetical nature of any price or income elasticities for substitutes, projections on the potential market for aquaculture products are difficult to make. Future

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(16) Aquaculture activities may also have beneficial environmental effects as traditional fisheries (e.g., processors) could profit from aquaculture through enhanced production. Aquaculture can also have a control function for other sources of pollution; for example, the excessive use of highly-toxic anti-fouling paints, such as TBT, on pleasure boats has been banned in many countries to protect the shellfish culture industry.

(17) "Talking Aquaculture in Layman's Terms," *St. Croix Courier* (N.B.), 17 May 1991, p. A5.

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increases in world seafood supply may be possible from species that are not yet normally caught for food, either because they are too difficult to catch and process or because they are unprofitable. In fact, new sources of supply, such as the "underutilized" species from traditional capture fisheries, are said to have already precipitated declining prices for some types of fish (e.g., groundfish). Some effort must therefore be put into developing innovative product forms for cultured products, with a view to making more profitable market niches.(18) Lastly, the international boom in aquaculture has raised the troublesome question of whether aquaculture output will disrupt markets now supplied principally by traditional commercial fisheries.

Although conditions and policies with respect to aquaculture vary from country to country, national public administrations and agencies usually provide the industry with the regulatory framework and services that create an environment favourable to growth. Public areas of responsibility encompass the regulation of access to sites, the conservation of coastal and freshwater environments, the control of diseases and introduction of non-indigenous species, the conduct of scientific and technological research, the formulation of national development policies, and the availability of adequate credit and insurance programs for the industry. Within countries, regions sometimes have a particular responsibility for stimulating and orienting the sector. Fish represent a major and growing deficit item in the trade balance of many developed countries, where the demand for highly-valued species is increasing. Developing countries, on the other hand, are very much aware that seafood for export has become a currency-earning commodity; in many cases, governments have set up national aquaculture development programs.

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(18) "Development of Commercial Strategies for Aquaculture Products," in *Aquaculture: A Review of Recent Experience*, Organisation for Economic Co-operation and Development, Paris, 1989, p. 165.

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AQUACULTURE IN CANADA

A. History and Background

Aquaculture in Canada has been practised for well over 100 years. Most of the early efforts were concentrated in the public sector; by the 1880s, the federal government was operating a wide network of fish hatcheries, many of which were later transferred to the provincial governments. In those early years, government hatchery production concentrated on salmon and trout and was geared to public stocking programs with small amounts of money going to research and development. This objective persists today with some added government responsibility for providing a small amount of broodstock to the private sector. Large-scale commercial production in Canada dates back to the 1950s, with trout and oyster cultivation in British Columbia and trout farming in Ontario.

Today, the industry is a mosaic of small family operations, publicly-owned and listed companies, and subsidiaries of large corporations involved in international seafood marketing and foreign-owned enterprises. The industry also varies across the country as to its nature, size and age, as well as the availability of accurate data, which varies with the province. The reasons for the growing interest in aquaculture may be listed as follows:

- Its demonstrated success in many other countries [and the prospect of high returns for investors];
- A strong and increasing market demand in Canada and export market for an assured supply of quality fresh fish and seafoods;
- Opportunities in Canada for the replacement of aquaculture imports (e.g., Norwegian salmon and Idaho trout);
- The employment and income that aquaculture generates, particularly in small coastal communities, as well as in a number of inland communities;
- The challenge of developing and applying the advances of science and technology to improve the quality of a basic resource and create new economic opportunities;

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- New developments in R&D, fish health and feed supply which have demonstrated the viability of the aquaculture of certain species (e.g., lobster);
- The growing interest in pay-angling aquaculture of freshwater fish near metropolitan centres;
- The recognition of the role for aquaculture in providing stock for wild fisheries; and
- Interest in the contribution that aquaculture can make to the support of the recreational and Native fisheries.(19)

Canadian aquaculture has seen remarkable growth over the past 15 years. In 1984, the annual value of the industry totalled $7 million; three years later, it had increased to $62 million. By the end of 1988, the value had increased again (by 76%) to reach $109 million or about 6% of the landed value of all Canadian fisheries.(20) Production in Canada, however, lags behind that of many other countries, such as Norway. The Canadian industry is still very much in its initial stages of development, perhaps because of the relative abundance of natural stocks, but certainly not because of lack of scientific expertise; this country has been, and still is, very much at the forefront of technology. The major species cultivated in Canada (discussed below) include salmon, oysters, mussels and trout; many others (e.g., cod, halibut, lumpfish), however, are reared on a small scale for developmental purposes or are on the verge of commercialization.

B. Industry Profile

1. Salmon Farming

Although salmon farming in British Columbia dates back to 1972, when the first commercial farm licence was issued, large-scale interest did not come about until the early 1980s. Throughout the 1970s and early 1980s, the industry suffered a number of setbacks, including low

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(19) Department of Fisheries and Oceans, *Developing Aquaculture in Canada: A Discussion Paper*, January 1986, p. 6.

(20) Department of Fisheries and Oceans, *Aquaculture: A Strategy for the 90s/Cultivating the Future*, Supply and Services Canada, 1990, p. 4.

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survival and growth rates, low profitability, undercapitalization and difficulty in obtaining financing. Beginning in 1984, however, there was a surge in the number of operating farms, and the increase in production was no less spectacular (Table 1).

B.C. salmon farms produce mainly Pacific salmon (chinook and coho), although a small number of sites have recently engaged in rearing Atlantic salmon, and some raise rainbow trout in saltwater. Nets are sewn in a bag-like configuration, suspended from floating support structures and anchored in protected inlets and coves. These so-called "grow-out" sites are located almost entirely on the province's south coast and on Vancouver Island. A few salmon farmers have integrated their operations so that they process and market their own product, while other growers have entered into contract arrangements with larger processors which provide their processing and marketing services on a commission basis. Some farmers have formed their own processing and marketing cooperatives, but most sell their fish through brokers or wholesale distributors. B.C. farmed salmon is shipped mainly to the United States, where about half of production is consumed and where it competes with fresh salmon from Norway, Chile, New Zealand, Japan and the United States.

Although some 25 B.C. salmon farms have gone into receivership since 1989,(21) rationalization had been expected after a period of staggering growth. The industry is now dominated by eight larger companies representing about three-quarters of total output.(22) While there may be a further decline in the number of corporate entities in the short term due to mergers and acquisitions and receiverships, the number of operating sites is expected to grow, albeit at a slower rate.(23) The main source

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(21) Department of Fisheries and Oceans, *Salmon Market Outlook,* Economic and Commercial Analysis Report No. 81, Supply and Services Canada, January 1991, p. 25.

(22) Department of Fisheries and Oceans, *Farmed Salmon Price Monitoring Study,* DFO Economic and Commercial Analysis Report No. 97, May 1991, p. 3, 5. The eight companies are B.C. Packers Ltd., Consolidated General Sea Harvest Corp., Hardy Sea Farms Inc., Ibec Aquaculture Corp., Pacific Aqua Foods Ltd., Pacific National Group Ent. Ltd., Scanmar Seafoods Ltd. and Sea Farm Canada.

(23) Price Waterhouse Management Consultants, *Long-Term Production Outlook for the Canadian Aquaculture Industry, (1990 edition),* Economic and Commercial Analysis Report No. 67, July 1990, p. 97.

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Table 1

Selected Statistics on Salmon Farming, by Region

The B.C. Salmon Farming Industry:

Year	Number of Operating Sites (1)	Production	
		Volume (tonnes)	Value ($000s)
1980	n/a	157	898
1985	37	120	820
1986	69	397	2,900
1987	118	1,362	10,280
1988	150	6,590	39,080
1989	135	12,400	75,000
1990 (2)	120 (3)	15,000	90,000

The Bay of Fundy (N.B.) Salmon Farming Industry:

Year	Number of Farms	Production	
		Volume (tonnes)	Value ($000s)
1980	2	11	82
1985	20	349	4,197
1986	28	635	8,078
1987	34	1,315	18,415
1988	34	3,250	32,000
1989	49	4,250	32,075

Notes:

(1) Licensed operations with fish in the water.
(2) Estimated.
(3) Sixty-eight companies operating in early April 1990. As at January 1990, there were 213 approved salmon farm tenures (203 licences and 10 leases), 33 investigative permits issued, and 60 new applications and amendments of development plans being reviewed by the B.C. Ministry of Agriculture and Fisheries.

Source: Price Waterhouse Management Consultants, *Long-Term Production Outlook for the Canadian Aquaculture Industry (1990 Edition)*, DFO Economic and Commercial Analysis Report No. 67, July 1990.

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of the industry's woes has been depressed prices; for example, between mid-1988 and August 1989, the price of B.C.-farmed chinook salmon (in the four to six-pound range) fell by 49%.

On the East Coast, salmon farming is a relatively recent development but one which is gaining in importance. The first experiments with Atlantic salmon aquaculture in the Maritime provinces were in Nova Scotia in 1969 and in New Brunswick in the early 1970s. The industry is concentrated in the Bay of Fundy in New Brunswick because ice restricts the use of salmon pens in other areas during the winter and because the Bay's powerful tides (the world's highest) provide one of the best environments anywhere for farming salmon.(24) The area currently has 48 salmon cage sites, four private salmon hatcheries, four major feed manufacturers, and 16 processing facilities. Three of the farms in the province are large, integrated operations representing about 85% of the Atlantic region's total production (Connors Brothers Ltd., Atlantic Silver Ltd., and Sea Farm Canada - a joint venture between Canada Packers Inc. and a Norwegian company).(25)

Although production in other areas of the Atlantic region is considerably smaller, salmon farming is expected to expand somewhat in Nova Scotia,(26) and to a lesser extent in Quebec and Prince Edward Island through the use of land-based systems. The major marketing channel for

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(24) In winter, the tidal currents churn the warmer water at the bottom of the bay to the ocean's surface, ensuring that the water temperature remains moderate enough for salmon to thrive. In summer, cold water from the ocean floor is forced to surface, preventing the spread of bacteria that multiply in warm water.

(25) John DeMont, "Rolling with the Tides: New Brunswick's Salmon Farms are Prospering," *Maclean's*, 8 July 1991, p. 49; Department of Fisheries and Oceans, *Farmed Salmon Price Monitoring Study*, May 1991, p. 5; "DFO Aquaculture Project Boosts Southwestern New Brunswick Economy," *The Guardian*, 11 April 1991, p. 3.

(26) Rob Gorham, "Aquaculture Has its Place in N.S.," *The Chronicle-Herald* (Halifax), 25 March 1991, p. 13. In N.S., there are eight hatcheries and 18 operating sites, eight of which grow a combination of marine trout and salmon. The other ten only grow marine trout. There is one major land-based facility in operation.

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Atlantic salmon farmers is a marketing cooperative (Atlantic Silver Ltd.), which sells fish on a commission basis mainly to wholesalers in Central Canada and the eastern seaboard of the United States. Worthy of note is the federal government's St. Andrews biological station and Salmonid Demonstration and Development farm in Lime Kiln Bay (N.B.), which play a major role in providing the industry with technical advice and support. An especially important competitive advantage is the region's roe herring fishery and the potential for additional feed manufacturing capacity from fish waste (i.e., herring carcasses).(27)

Canada produced some 23,000 tonnes of farmed salmon in 1990. Though having developed very rapidly, Canada's production remains small when compared to that of Norway, the first country to export significant volumes of farmed salmon and the world's largest producer and exporter (Table 2). Norway, which acquired much of its expertise in rearing salmon from Canadian scientists in the mid-1960s and 1970s, dominates world salmon farming. It not only accounts for over half of global production, but also sets the standards and refines the equipment and techniques for the rest of the world. Smolt producers, feed manufacturers, growers and exporters have shared in a remarkable era of expansion: production in 1990 has been estimated at 150,000 tonnes, compared to about 100 tonnes in 1971. This growth, however, has not been achieved without difficulties as sharp increases in output in recent years have disrupted world markets. As a result, salmon prices declined, impairing the profitability of the industry. A freezing program was introduced in January 1990 as a means of controlling excess production of fresh salmon and to reverse the slide in prices; this was viewed by other producers (competitors) as a positive initiative on Norway's part. To prevent a further erosion in price, farmers have not only intentionally limited their harvest but also reduced their production of smolts.

Norway was found guilty of dumping salmon (selling at below production cost) in the United States during a downturn in the market in

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(27) Once the roe is extracted, the remaining carcass constitutes 93% to 95% of the fish by weight. One major feed manufacturer in N.B. reportedly uses over 30,000 tonnes of herring carcasses annually.

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Table 2

Worldwide Production of Farmed Salmon, 1981-1989
(tonnes)

A. Farmed Atlantic Salmon

	1981	1982	1983	1984	1985	1986	1987	1988	1989
Norway	8,910	10,266	17,016	22,300	28,655	45,675	47,417	80,300	117,000
Scotland	1,000	2,100	2,536	3,912	6,921	10,300	12,600	17,600	28,500
Ireland	35	103	257	385	650	650	2,500	4,200	6,200
Faroe Islands	100	130	160	300	450	600	2,500	3,400	6,000*
Iceland	20	30	50	70	90	100	1,000	1,300	1,800*
Eastern Canada	28	48	126	163	188	297	1,300	3,300	4,600
Other	60	80	100	75	300	390	400	1,990	3,220*
Total	10,153	12,757	20,245	27,205	37,254	58,012	67,717	112,090	167,320

B. Farmed Coho and Chinook

	1981	1982	1983	1984	1985	1986	1987	1988	1989
B.C.	176	273	128	107	120	397	1,362	6,590	12,400
Chile	60	80	100	270	870	1,000	1,600	3,100	6,680
Western U.S.	450	680	900	1,176	1,257	1,507	2,000	1,900	4,000
Japan	1,150	2,122	2,760	5,049	6,430	7,220	12,000	14,060	17,100
New Zealand	2	5	10	20	500	500	1,500	1,650	2,000*
Other	60	80	80	90	100	180	200	200	200*
Total	1,898	3,240	3,978	6,712	9,277	10,804	18,500	27,500	42,380

* Preliminary estimates.

Sources: Price Waterhouse Management Consultants, *Long-Term Production Outlook ...*, July 1990; Department of Fisheries and Oceans, *Salmon Market Outlook*, Economic and Commercial Analysis Report No. 81, Supply and Services Canada, January 1991, p. 26.

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1989. Under U.S. anti-dumping legislation, the U.S. Department of Commerce imposed a 26% levy on Norwegian salmon imports. Since then, the Norwegian industry has turned its attention to the Japanese market.(28) It is also noteworthy that Norwegian regional development policies have restricted the size and ownership of individual farms and give priority to small-scale family businesses so as to sustain local employment and land occupation.(29) Partly because of this, some companies have invested heavily in British Columbia and elsewhere. Although the number of farms in Norway has not increased significantly since the mid-1980s, capacity was considerably expanded in 1988 when the government allowed growers to increase the size of individual farms from 8,000 to 12,000 cubic metres.

On the marketing front, since 1978 the Norwegian industry has had an organization (the Norwegian Fish Farmers Sales Organization), which is owned by the fish farmers and which has a legislative monopoly on all sales of farmed fish. Much of Norway's success in salmon farming can be attributed to a consolidated approach to exporting and marketing, and industry-funded generic promotions.(30)

Scotland, the Faroe Islands, Japan, Chile, Iceland and other countries are also emerging as important world producers of farmed salmon. In short, total output is expected to easily surpass the 1990 level of 270,000 tonnes (which represents about 27% of the total world salmon supply);(31) the rate of growth in production, however, will likely

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(28) Department of Fisheries and Oceans, *Salmon Market Outlook,* January 1991, p. 29.

(29) There were about 785 operating sites in 1990, employing about 4,000 individuals.

(30) Department of External Affairs and International Trade, Fisheries Division, *Report on Aqua Nor '89,* 1990, p. 4-6; Standing Senate Committee on Fisheries, *The Marketing of Fish in Canada: Report III on the East Coast Fisheries,* December 1989, p. 100.

(31) World annual landings of wild Pacific and Atlantic salmon are predicted to remain stable at about 700,000 to 800,000 tonnes. Farmed salmon represented only about 5% of total world salmon supplies in 1985.

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decline to an average of about 5% for the period 1990-1993, compared to the 50% to 60% experienced in 1988 and 1989.(32)

2. The Cultivation of Blue Mussels

Virtually all blue mussels produced in Canada are from the Atlantic region (Table 3), with Prince Edward Island boasting the greatest success to date with about 70% of total national output. Almost all blue mussels produced in Canada are from cultivated stocks, using off-bottom techniques rather than bottom culture.(33) Typically sold fresh (unprocessed in the shell) as a premium product at a premium price, Canadian mussels compete primarily with the semi-cultivated (and lower-quality) product from the United States, mainly from the eastern seaboard. Worldwide, cultured mussels represent about 80-85% of the total harvest; major producers include France, the Netherlands, Spain, Denmark, Germany, China, Thailand and Korea. An important part of any marketing strategy, therefore, lies in convincing consumers of the superiority of the Canadian product. To date, some promotion has been conducted by the P.E.I. Development Agency.

3. Oyster Culture

Oyster culture takes place on Canada's both coasts, with the American (or Belon) oyster and the Pacific oyster being the major species. The European oyster, although produced in smaller quantities in the Atlantic provinces is, however, the most highly valued species.

The cultivation of Pacific oysters in B.C. started at the beginning of the century when stocks were imported from Japan. Commercial

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(32) B.C. Salmon Farmers Association, *Current Developments in World Salmon Markets...*, DFO Economic and Commercial Analysis Report No. 46, January 1990 (addendum).

(33) The off-bottom method consists of growing mussels by suspending them from surface floats. Estimates of mussel production for eastern Canada vary depending on the source of information. British Columbia produces a very limited supply of mussels; commercial ventures have not proved feasible because of predation by diving ducks, a high rate of pre-harvest mortality, and a high rate of fouling by organisms such as barnacles and tunicates.

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Table 3

Selected Statistics on Mussel and Oyster Culture, by Region

Mussel Farming in Canada:

	Production	
	Volume (tonnes)	
Province	1987	1988
Prince Edward Island	1,035	1,441
Nova Scotia	257	321
Newfoundland	80	80
Quebec	80	92
New Brunswick	10	111
British Columbia	2	2
	1,464	2,047

	Production in P.E.I.
	Volume (tonnes)
Year	
1978	12
1979	14
1980	49
1981	47
1982	70
1983	163
1984	285
1985	465
1986	1,220
1987	1,035
1988	1,441
1989	2,682

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Table 3

(cont'd)

Oyster Farming in B.C.:

Year	Lease Holders	Issued Licences	Production (tonnes)	Value (1) ($000s)
1977	71	177	2,998	981
1978	78	202	2,793	1,021
1979	80	208	2,231	893
1980	101	239	1,922	1,134
1981*	114	250	1,415	1,030
1982*	145	282	1,579	981
1983*	164	303	2,453	1,554
1984*	168	310	2,897	2,109
1985*	188	334	3,420	2,613
1986*	200	350	2,864	2,500
1987*	249	385	3,000	3,000
1988	265	437	3,701	2,726
1989	n/a	422	3,900	3,000

Oyster Production in the Atlantic Provinces:

	Production (tonnes)		Number of Leases
Province	1988	1989	1989
New Brunswick	611	426	850
Prince Edward Island	1,461	1,895	1,004
Nova Scotia	140	101	220
Total	2,212	2,422	2,074

Notes:

* Includes a small harvest of wild oysters from picking permits.
(1) Wholesale value.

Source: Price Waterhouse Management Consultants, *Long-Term Production Outlook...*, July 1990.

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production began in the early 1950s, rising to a peak harvest of some 5,900 tonnes in 1963, but then declining because of poor growing techniques and too much reliance on natural oyster seed. Since 1981, when production was 1,415 tonnes (an all-time low), the volume of output increased to about 3,700 tonnes in 1989, mainly due to the development of hatcheries and improved technology, especially off-bottom culture techniques. B.C. oysters are sold either shucked or in the half-shell, primarily in the domestic market. A marketing board (the B.C. Oyster Board) administers policies regarding licensing, product pricing, transportation, packing and packaging, and storage of both wild and farmed oysters. Marketing channels are either direct sales by producers/processors to final markets, or sales through wholesalers.

Commercial production in eastern Canada is primarily restricted to New Brunswick, Nova Scotia and Prince Edward Island. Summer seawater temperatures determine the spawning success and survival of the American oyster; favourable conditions for cultivation include those in the southern Gulf of St. Lawrence and the Bras d'Or Lakes on Cape Breton Island, the Northumberland Strait, and sheltered areas on the Atlantic coast of Nova Scotia.(34) Of the 850 leases held in New Brunswick in 1989, about 10 lease holders purchased seed for grow-out on private beds; about 75% of oyster production came from public beds. In P.E.I., most oysters are harvested in the spring from public beds and moved to privately-leased beds for re-harvest in the fall. Only about 10% of the leases in P.E.I. are held by active commercial operators.

4. Trout Farming

Trout farming in Canada started more than 100 years ago primarily in freshwater hatcheries established by governments and industry for resource enhancement. Current operations focus mostly on freshwater rainbow trout(35) and supply three major markets: pond fishing

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(34) Some consider the Belon oyster an ideal species for culture in the oceanic waters off N.S., where commercial production was established in 1988. Price Waterhouse Management Consultants, *Long-Term Production Outlook...*, July 1990, p. 58.

(35) Some aquaculturists have also been rearing trout in sea cages, primarily in Nova Scotia. Brook trout is extensively raised for pond fishing and enhancement in Quebec.

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Table 4

Production of Freshwater Trout, by Province, Selected Years (1)

Year	B.C.	Ontario	Quebec (2)	Atlantic (3)
1970	n/a	91	n/a	n/a
1980	56	408	n/a	83
1985	83	544	n/a	-
1986	101	1,134	n/a	111
1987	115	1,451	130	150*
1988	115*	1,814	250	150*
1989	125*	1,925	260*	150*

Notes:

* Estimated.
(1) Excludes marine trout production estimated at about 184 tonnes for Nova Scotia in 1989, 100 tonnes in other Atlantic provinces, and about 300 tonnes in B.C.
(2) Figures provided by the Quebec Ministry of Agriculture.
(3) Estimates for 1987, 1988 and 1989 are conservative, given that 1989 production in P.E.I. alone reached 70-75 tonnes.

Source: Price Waterhouse Management Consultants, *Long-Term Production Outlook...*, July 1990.

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(angling), lake and river stocking, and food for human consumption. Commercial production for food began about 30 years ago in Ontario, and the industry has since made inroads in all provinces to varying degrees. Throughout Canada, trout farming represents an alternative source of income to traditional farming (agriculture).

In Canada, most operations use groundwater, taken from the head of springs or artesian wells, which is better suited to farming trout than surface water. Accordingly, many of the farms in Ontario, Canada's leading trout producer for the food market, are located in south central and southwestern Ontario; many are on the Niagara escarpment, where there are fairly large volumes of groundwater. Ontario trout farms range from small family operations to large and diversified corporate entities that are involved in other activities such as tobacco farming. Most farmers market their products through a cooperative.(36) Canadian trout products, which are largely sold fresh in the domestic market (though increasing amounts are being smoked) generally do not compete directly with imports. In 1989, major world producers of freshwater rainbow trout were Italy (32,000 tonnes), Denmark (30,000 tonnes), France (20,000 tonnes), the United States (22,000 tonnes) and Japan (between 15,000 and 20,000 tonnes). Approximately 70% of production in the United States is from Idaho, which has an exceptional supply of freshwater from what is referred to as the "Snake River Plains Aquifer." The Clear Springs Trout Company in that State has become the largest producer of fish in the U.S.(37)

5. Other Species

Because of the abundant supply of certain types of farmed fish (e.g., salmon), there has been great interest in the commercial production of other or alternative species. The relative ease of culture

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(36) In B.C., a few aquaculturists produce rainbow trout and are engaged in processing and marketing. In the Prairie provinces, marketing of locally-produced trout is usually done by brokers. In Quebec, the fish is sold to an association for further marketing.

(37) Kathrine Marris, "Fish Wranglers of Idaho," *Seafood Business*, Vol. 10, No. 1, January/February 1991, p. 133.

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of Arctic char, for example, and high market demand have made this species attractive to aquaculturists, especially to farmers of trout. Trout also requires similar rearing techniques. Research and development into Arctic char farming began in 1978 at the Rockwood Experimental Hatchery in Manitoba. Although cultivation is still in its early stages(38) and meaningful growth projections for the sector are difficult to establish, it is reasonable to expect substantial increases in future supply.

Research into scallop farming began in Canada in the late 1960s, but initial culture attempts were largely unsuccessful. Renewed interest developed in the 1980s as a result of the depletion of wild stocks; at least 20 research facilities and commercial operators are now involved in aquaculture of Sea scallops, Bay scallops and Japanese scallops. Although there is not yet significant commercial production of farmed scallops in Canada, a small volume (20 tonnes in 1989) of Bay scallops has been produced in the Maritime provinces. Scallops are cultivated in many countries throughout the world, but Japan, which has been farming the shellfish for the last 20 years, is by far the largest producer.

C. Production and Employment Projections

A recent study commissioned by the federal Department of Fisheries and Oceans projects future growth of the Canadian industry both in terms of production and employment (Table 5). Two assumptions form the basis of the analysis. First, it uses a narrow definition of the aquaculture industry as it considers only grow-out sites. Second, it does not take into account the substantial backward and forward linkages to hatcheries, processing plants, feed and equipment manufacturers, transportation, marketing and consulting services that form an integral part of the sector. Thus, the projections underestimate, to some extent, the levels of activity and employment attributed to aquaculture. Another recent forecast suggests that, by the year 2000, the sector could reach annual values of $500 million to $1 billion.(39)

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(38) Commercial production of Arctic char was estimated at about 7 tonnes in 1979.

(39) Department of Fisheries and Oceans, *Aquaculture: A Strategy for the 90s...*, 1990, p. 4.

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Table 5

Production and Employment Projections, by Species and Region

Production Projections
(tonnes)

	Salmon			Oysters		
	1989	1995	2000	1989	1995	2000
B.C.	12,400	20,000-30,000	30,000-60,000	3,900	5,000- 7,000	6,000-12,000
Atlantic Canada	4,250	7,600-12,000	9,000-15,500	2,400	3,000- 5,000	4,000- 7,000
Total	16,650	27,600-42,000	39,000-75,500	6,300	8,000-12,000	10,000-19,000

	Mussels			Marine Trout (1)		
	1989	1995	2000	1989	1995	2000
B.C.	-	-	5- 200	300	1,000- 3,000	2,000- 5,000
Atlantic Canada	3,000	3,500- 5,000	4,300- 7,000	300	1,000- 2,000	1,500- 3,500
Total	3,000	3,500- 5,000	4,305- 7,200	600	2,000- 5,000	3,500- 8,500

	Freshwater Trout		
	1989	1995	2000
B.C.	125*	150- 300	200- 600
Atlantic Canada	150*	150- 200	200- 300
Ontario	1,925	2,500- 3,500	3,000- 4,500
Quebec	260	500- 1,000	600- 1,500
Prairies and Territories	100	100- 200	100- 400
Total	2,560	3,400- 5,200	4,100- 7,300

Note:

* Estimated, based on 1988 production.

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Table 5

(cont'd)

Employment Projections
(full-time equivalent positions)

	Salmon			Oysters		
	1989	1995	2000	1989	1995	2000
B.C.	800	950- 1,000	1,050- 1,800	225	250- 350	300- 600
Atlantic Can/Que	300	315- 540	315- 600	120	150- 250	200- 350
Total	1,100	1,265- 1,540	1,365- 2,400	345	400- 600	500- 950

	Mussels			Marine Trout		
	1989	1995	2000	1989	1995	2000
B.C.	-	-	0- 20	10	40- 110	75- 185
Atlantic Can/Que	200	230- 330	280- 450	20	40- 75	55- 130
Total	200	230- 330	280- 470	30	80- 185	130- 315

	Freshwater Trout			Total		
	1989	1995	2000	1989	1995	2000
B.C.	10	10- 25	15- 50	1,045	1,250- 1,485	1,440- 2,655
Atlantic Can/Que	30	50- 95	65- 150	670	785- 1,290	915- 1,680
Ontario	160	200- 290	250- 375	160	200- 290	250- 375
Prairies and Territories	10	10- 15	10- 30	10	10- 15	10- 30
Total	210	270- 425	340- 605	1,885	2,245- 3,080	2,615- 4,740

Note:

Data represent employment in terms of full-time equivalent jobs. The assumptions upon which these estimates have been based are shown below, by species:

cont'd.

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Table 5

(cont'd)

Salmon:

B.C.	Five full-time equivalent positions per site: based on existing average employment figures.
New Brunswick	Six full-time equivalent positions per site: based on existing employment levels and observations of the increased capacity of farms in New Brunswick.
Quebec/ Newfoundland	Ten full-time equivalent positions per site: increased labour intensity caused by land-based systems used in these provinces.

Oysters:

B.C.	20 tonnes/person-year equivalent or five full-time equivalent positions per site: based on existing employment levels.
Eastern Canada	20 tonnes/person-year equivalent or five full-time equivalent positions per site: B.C. methodology used as no data were available on average numbers of employees per operating site.

Mussels:

All Canada — 15 tonnes per full-time equivalent positions: based on the following assumptions:

- labour cost component of production is 40% of wholesale value;
- wholesale price of $1/lb.;
- average labour cost of $8/hour; and
- average number of hours worked per full-time equivalent position - 1,500 hours.

Freshwater Trout:

All Canada — 12 tonnes per full-time equivalent positions: based on the following assumptions:

- labour cost component of production is $1/kg;
- average labour cost of $8/hour; and
- average number of hours worked per full-time equivalent position - 1,500 hours.

Marine Trout:

All Canada — 27 tonnes per full-time equivalent position: based on the assumption that marine trout farms are more capital intensive than freshwater trout farms.

Source: Price Waterhouse Management Consultants, *Long-Term Production Outlook...*, July 1990.

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D. Industry Representation

Until recently, Canadian aquaculturists were not generally well-organized; in some regions of the country, there were loose associations, but these were the exception. With the growth of the industry, however, aquaculturists became more aware of the need to facilitate the flow of information among themselves, especially with respect to market forecasts, production methods and technologies, and quality standards. Two national associations now exist in Canada: the Canadian Aquaculture Producers' Council, and the Aquaculture Association of Canada.(40) In addition, fish farmers have formed associations representing various areas of interest (e.g., species-specific, geographically specific within a province, or provincial).(41) Membership size varies with the sector, and some groups are more established and active than others. Cooperative organizations have also been established in several regions for the processing and marketing of several types of products.

Industry organizations are not only important to their individual membership, they are also of much importance to governments.

> Given the strong commitments made by both the federal and the provincial governments to rely on the private sector to establish new ventures and to market their products, the industry's success is mostly in its own hands. In declaring that their role is largely supportive and facilitative, governments must rely on these organizations to represent their membership in government/industry consultations. Over the last several years, governments at both levels have been holding regular discussions with industry on national and provincial programmes and plans, legislation,

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(40) The Aquaculture Association of Canada was created in 1983 to foster development by promoting research, communication and education. The Canadian Aquaculture Producers' Council was formed in January 1987 to provide a unified voice for the industry and to promote communication with governments and other relevant groups.

(41) For example, the N.B. Salmon Growers' Association, the Eastern N.S. Mussel Growers, the Ontario Trout Farmers' Association, the Syndicat des pisciculteurs du Québec, and the B.C. Farmers' Association.

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> various support services, and other areas of mutual interest. These joint effects are certain to continue and probably intensify as the industry grows to become a significant contributor to the national fisheries and the national economy as well as an important element in our continuing efforts for improved regional development.(42)

E. The Federal Government's Response to Development

The federal and provincial governments reacted to the industry's rapid expansion in the 1980s by passing legislation or regulations aimed at managing growth, protecting the traditional capture fisheries; and minimizing possible conflicts with other user groups. This, in turn, increased the legal and administrative burden on existing and prospective aquaculture operators. As aquaculturists became more organized, however, they began to express their views and expectations more clearly and forcefully to governments. Specifically, the industry requested that federal, provincial and municipal governments "get their houses in order" on matters dealing with aquaculture. They asked governments:

- To assign a high priority to aquaculture;
- To name a "lead agency" for aquaculture at each level of government;
- To develop policies, plans and supportive programs;
- To encourage intragovernmental and intergovernmental co-ordination of efforts;
- To establish supportive legislation specifically for aquaculture and to eliminate duplication between various statutes and jurisdictions; and
- To clarify and simplify the regulations governing all aspects of aquaculture.(43)

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(42) Colin MacPherson, "A Co-ordinated Approach to Aquaculture in Canada," in *Aquaculture: A Review of Recent Experience*, Organisation for Economic Co-operation and Development, Paris, 1989, p. 204.

(43) *Ibid.*, p. 198.

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1. The 1986 Conference of First Ministers

Public discussion was further stimulated by the Report of the 1983 National Aquaculture Conference, the Science Council of Canada's 1984 Industry Task Force on Aquaculture, and the Science Council's 1985 Statement on Aquaculture. These discussions resulted in a year-long effort by Canada's Fisheries Ministers to consult with industry, technical experts and the general public and in the production of a "Report on Challenges Facing the Fishery Sector." In this document, which was subsequently endorsed by the Prime Minister and the provincial Premiers at their 1986 Annual Conference, Fisheries Ministers agreed to increase federal-provincial co-ordination to ensure orderly development of the aquaculture industry. They agreed:

- To encourage the development of commercial aquaculture in Canada in a manner that is complementary to the continuing development of the wild fishery;
- To increase the economic returns from intensified production and harvest of high value, marketable species of finfish, shellfish and marine plants in the regions of Canada;
- To improve the quality and expand the variety of Canadian fish products;
- To improve the reliability of supply of Canadian products to be marketed in Canada and abroad;
- To create new employment and enriched income opportunities in the production of fish;
- To encourage the long-range stability in the country's fish production sector through diversity and continuity of supply; and
- To promote the development and application of the most advanced technologies for intensive production and marketing of finfish, shellfish and marine plants across Canada.

In pursuit of these goals, Fisheries Ministers adopted the following basic principles:

- The private sector should be relied upon to establish aquaculture ventures and to market the resulting products, taking advantage of existing structures where applicable;

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- The federal government and the provinces/territories should co-ordinate their efforts to ensure the orderly development of commercial aquaculture in Canada;

- Memoranda of Understanding to promote commercial development should be entered into on a bilateral basis so as to recognize regional differences;

- The regulatory frameworks of governments should be clarified for commercial aquaculture development;

- Government programs should provide support to the aquaculture industry in some key stages of development;

- The federal government should continue to maintain a responsibility for fish health in general, including all cultured species;

- Continuing dialogue between the aquaculture industry and governments should be encouraged; and

- In order to improve the technological basis for commercial aquaculture, governments should work co-operatively with industry in promoting and conducting R&D and transferring the resulting benefits.

Fisheries Ministers agreed to negotiate Memoranda of Understanding on aquaculture development to establish the framework for federal-provincial involvement in each province. Key provisions would be:

- "One stop" licensing and leasing of commercial aquaculture ventures by the provinces; and

- Federal-provincial co-operation to promote the orderly development of the industry.(44)

2. Memoranda of Understanding

Unlike the situation for the common property fishery (i.e., the traditional fishery), the federal and provincial governments share jurisdiction over aquaculture. Under the Constitution, the federal government has jurisdiction over "sea coast and inland fisheries," but the provinces have significant responsibilities for "property and civil rights" (e.g., for leasehold arrangements). As stated in the 1986 Report of First

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(44) Government of Canada, *Report on Challenges Facing the Fishery Sector*, Annual Conference of First Ministers, 20-21 November 1986, Vancouver, B.C., 1986, p. 3-4.

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Ministers, the framework for co-operative action on aquaculture is made up of the federal-provincial Memoranda of Understanding (MOUs); these are meant to establish mutually agreeable delineations of administrative responsibilities for the regulation of the industry and to overcome jurisdictional complexities.(45)

Because of varying regional differences in the aquaculture sector, the extent and type of government involvement and capabilities, and local circumstances, the agreements are structured to meet prevailing and anticipated needs, and are consequently negotiated bilaterally between the federal government and the individual provinces. MOUs are a means of developing a co-ordinated and co-operative plan for government support for the industry, but are not meant to be a funding mechanism and therefore contain no provisions for resource allocation. They generally contain the following elements: authority and purpose, genera or species to be included, research and development, education and training, leases and licensing, fish health, statistics, implementation, and national co-ordination. Various federal, provincial and industry advisory committees have been established under the MOUs.

3. Ongoing Federal Government Support

In addition to Memoranda of Understanding, both levels of government undertake separate activities in support of aquaculture. By and large, the provinces address local conditions in their jurisdiction (e.g., financial conditions, specialized research and development requirements). The federal government, on the other hand, generally focuses on regional or national considerations. Through its ongoing programs, the DFO provides support in a number of areas, several of which are encompassed in the MOUs. In summary, DFO programs include:

- Research and experimental development, collaborative research with industry, operation of fish hatchery and fish culture facilities, disease diagnostic services, and the development of

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(45) MacPherson (1989), p. 205.

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protocols for the safe movement of non-indigenous stocks and the introduction of new genetic resources;

- Conducting habitat reviews and, in some instances, supplies eggs and smolts in some areas of Canada, and fisheries development;
- The implementation of the National Fish Inspection Program;
- The operation of a national system of 1,400 commercial fishing harbours;
- Advancing Canada's fisheries conservation and trade interests through the international community;
- Providing governments and the industry with relevant market intelligence and analysis;
- Collecting and disseminating national statistics on aquaculture and maintaining a national data base; and
- Providing a regular array of scientific and technical publications on relevant scientific developments.(46)

Many other federal departments and agencies provide assistance directly and indirectly, as follows:(47)

- Supporting research and development activities in industry or the university sectors, either of general interest or sector-specific, and technology transfer;
- Supporting or stimulating economic activity in specified regions of the country, within particular economic sectors, or by certain segments of the Canadian society;
- Supporting small or medium-sized business development by offering various forms of financial support, marketing assistance, and other specialized business expertise; and

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(46) *Ibid.*, p. 203.

(47) Examples are the National Research Council, the National Sciences and Engineering Council, the Department of Employment and Immigration, and Environment Canada. In 1988, the DFO published for the first time a compendium of federal aquacultural programs entitled "Aquaculture Development in Canada: A Guide to Federal Government Programs."

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- Providing tax rebates or exemptions for specific economic sectors, tax incentives for regional development, or special capital cost allowances for specified equipment.(48)

Assistance is also available through provincial programs. Some provinces rely on Subsidiary Agreements under federal-provincial Economic and Regional Development Agreements (ERDAs) established by the Atlantic Canada Opportunities Agency (ACOA). In May 1990, the Minister of Fisheries and Oceans announced a five-year, $584-million Atlantic Fisheries Adjustment Package (AFAP) that committed $50 million towards diversifying the fishing industry. Approximately one-quarter of the funds are to be reserved for aquaculture research and development, technology transfer and pilot projects.(49) An Aquaculture Science Advisory Board has been established, representing the industry, universities and the federal and provincial governments, to set policies and priorities for AFAP-sponsored science projects. As at June 1991, 72 aquaculture research proposals had been screened and 33 approved for 1990-91.

In 1988, the DFO reportedly undertook to develop an aquaculture strategy, which was subsequently announced in the spring of 1990. The Department's five goals are the following:

- Support through scientific and technological leadership and innovation;
- Sound co-operative management for a healthy and productive aquatic environment;
- An inspection system to support the industry's reputation for high-quality cultured products;
- Provision of market and commercial analysis and advice to assist Canadian aquaculturists to capitalize on market opportunities; and
- Advocacy and dialogue to promote sustained growth and development of the aquaculture industry.(50)

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(48) MacPherson (1989), p. 203.

(49) Department of Fisheries and Oceans, *Aquaculture: Profile of Federal Activities*, Supply and Services Canada, 1990, p. 4-5.

(50) Department of Fisheries and Oceans, *A Strategy for the 90s...*, 1990, p. 8.

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F. Educational Institutions and Training

A number of post-secondary educational institutions in the country are actively involved in aquaculture. Traditionally, several universities have assisted industry development with their existing research capabilities; in more recent years, some schools have begun offering undergraduate and post-graduate courses and programs in aquaculture.(51) In addition to specialized research, some institutions (for example, Malaspina College in Nanaimo, B.C. and the Huntsman Laboratory in St. Andrews, N.B.) offer technical training in aquacultural management in such areas as fish health and hatchery techniques. Under MOUs, the provinces generally take the lead in promoting education and training, while the federal government assists, where applicable, by facilitating access to federal facilities for practical training.

CONCLUSION

The Canadian aquaculture sector has expanded since the early 1980s and forecasts indicate that this growth will continue (Tables 6 and 7). Although the Canadian industry enjoys a number of competitive advantages over other world producers, there are constraints to further development, depending on the species and region in question. Governments acknowledge aquaculture's potential and are prepared to support it, but as the industry matures and private sector capabilities increase, it is expected that government support will diminish accordingly and success will largely be the result of the industry's own efforts.(52)

Worldwide production volumes from aquaculture have, to some extent, contributed to a world drop in prices. The trend towards increasing seafood supplies from fish farming may further depress prices; this should make Canadian producers wary about future markets and brings marketing and new product development very much to the fore.

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(51) The Technical University of Nova Scotia, through the Canadian Institute of Fisheries Technology in Halifax, the Atlantic Veterinary College at the University of Prince Edward Island, and the University of Guelph in Ontario.

(52) MacPherson (1989), p. 204.

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Table 6
Canadian Industry Strengths, by Type and Major Species

	Species							
	Salmon		Mussels	Oysters		Trout	Arctic Char	Scallops
Strength	B.C.	East Coast	East Coast	B.C.	East Coast			
Close proximity to the U.S.	*	*	-	-	*	*	-	-
Close proximity to markets (other than U.S.)	*	-	-	-	-	-	-	-
Strong or increasing market demand	-	-	-	*	-	-	*	-
The potential for increased market demand	-	-	-	-	*	-	*	-
The development of a marketing strategy	-	-	-	*	-	-	-	-
The potential for effective marketing campaigns	-	-	-	-	*	-	-	-
The production of high-quality or premium products	-	-	*	-	-	*	*	*
Low production costs (general)	*	*	-	-	-	-	-	-
Low labour costs	-	*	-	-	-	-	-	-
A well-trained work force	*	*	-	-	-	-	-	-
A well-established activity and a network of experts	-	-	-	-	-	*	-	-
Scientific support and expertise	*	*	-	-	-	-	-	*
Abundance or ready availability of smolt/seed supplies	-	-	*	-	-	*	-	-
Relative ease of culture or length of grow-out cycle	-	-	-	-	-	-	*	*
Availability of high-quality sites	*	-	-	-	-	-	-	*
Government regulations comparable to other countries or conducive to growth	*	*	*	-	-	-	-	-

Source: Price Waterhouse Management Consultants, *Long-Term Production Outlook...*, July 1990.

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Table 7

Major Constraints to Further Aquacultural Development in Canada, by Type and Major Species

	Species							
	Salmon		Mussels	Oysters		Trout	Arctic Char	Scallops
Constraint	B.C.	East Coast	East Coast	B.C.	East Coast			
Competitive markets	*	*	-	*	-	*	-	*
Weak markets	-	-	-	-	*	-	-	-
Economic viability not established	-	-	-	-	-	-	-	*
Lack of consumer recognition	-	-	-	-	-	-	*	-
Variable or limited size of end-product	-	-	-	-	-	-	*	*
Insufficient financing and cash flow problems	*	*	*	*	*	*	-	-
High production costs (in general)	-	-	*	-	-	*	-	-
High labour costs	-	-	-	*	-	-	-	-
Limited availability of suitable sites	-	*	*	*	*	*	-	-
Limited or low-quality supply of smolts/seed/broodstock	-	*	-	*	*	-	*	*
Limited genetic strains	-	-	-	-	-	-	-	*
Blooms, diseases and other biophysical factors	*	*	*	*	-	-	-	*
Developmental problems requiring further R&D	*	-	-	-	*	-	*	-
Opposition from environmental lobby, property owners and other users of the waterways	-	*	-	-	-	-	-	-

Source: Price Waterhouse Management Consultants, *Long-Term Production Outlook...*, July 1990.

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